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portion to the glycerin or acrolein used. The importance of these researches lies in the fact that they show how the chemical changes which characterize the vital action of the plant can be imitated with dead matter, and that, further, they shed a bright gleam of light on the hitherto obscure question of the arrangement of the indivisible particles, atoms, within the compound particles, the molecules of these substances.

Our supply of sugar will always be drawn from the vegetable kingdom, the synthetic laboratory of nature. Many plants work hard and economically at the production of sugar, and form it in quantity. It occurs in all parts of plants, — root, stem, leaves, flower, fruit, and seed. In some grasses it is very abundant, in the sugar-cane, in the sorgho grass, and in the young shoots of the maize. In the common carrot and parsnip, and especially in the fleshy beet, large quantities are contained. But for its commercial extraction two sources are chiefly used — the sugar-cane and the beet-root, and a third is of growing importance, the sorgho grass.

The sugar-cane has far greater natural advantages than the beet-root. At one time the former held the field without a rival. But during the Napoleonic wars, France was deprived of her supply of sugar, and she was driven to produce her sugar at home. This resulted in the commencement of the beet-sugar industry, and thus amongst the secondary results of war must be reckoned bounty-fed sugar. To judge of the economic aspects of the two industries, many factors have to be taken into account. When that has been done, this balance will be found distinctly in favor of the cane. Sugar-canes contain sufficient sugar to yield seventy to eighty per cent of their weight of juice, in which there is some twenty per cent of sugar. Beet-roots, as an extended series of investigations have shown, possess a percentage of sugar varying from seven to a maximum of under fourteen, and on the average about eleven. Now an acre of land which can be used for beet-growing will be rented for, say, £4 per annum, while in the colonies an equal area of cane-producing land will be rented for about one-tenth of that amount.

Further, a great divergence is found in the quantity of beet and cane which two equal areas can grow. For instance, in the environs of Magdeburg, an acre will yield about ten hundred-weight of sugar; whereas, in the home of the sugar-cane, some forty to fifty hundred-weight can be obtained. Then other items in the cost of production have to be considered; the difference in wages in the two regions, the difference in the cost of fuel, — in Europe where coal is necessary, in the colonies where the waste matter of the cane supplies the whole, or nearly the whole, of the fuel required. One can thus realize the grounds on which the Brazilian commission on the sugar industry reported, that, in their opinion, "the cost of production may be reduced in Brazil to such a degree as to defy competition, and the struggle between cane and beet-root must become ominous to the latter, which thrives only by the artificial advantages which European countries have devised."

Hitherto the artificial advantages have been on the side of the European countries; but now the greatly improved means of transit, and the diffusion of knowledge, are raising the colonists to a position nearer equality in these respects, of course excluding bounties. And by this time the colonial sugar planter has learned a severe lesson. He understands that, while nature has showered her gifts on him with a lavish hand, she mercilessly punishes him for carelessness and lack of promptitude. For if he cuts his canes, they must within a few hours be crushed and extracted; if he is negligent, and leaves them for only two days, fermentation rapidly ensues under the conditions of tropical temperature, and the canes turn sour and must be thrown aside for fuel. In this way nature has fined men whole fortunes.

FATTENING LAMBS.

At the Cornell Agricultural Experiment Station some experiments have been carried out recently on the effect of different rations on fattening lambs, under the direction of Professors J. P. Roberts and Henry H. Wing. These experiments were, in the main, a continuation of those carried on at this station one year ago, and very nearly the same foods were used, none of them being out of the reach of the general mass of farmers.

The period of feeding lasted five full months, from November 25, 1888, to April 25, 1889. The lambs, twelve in number, were selected from a lot that had been picked up in the surrounding country for shipment. They were coarse wool grades, Shropshire or Southdown, dropped late the previous spring, and had evidently been scantily fed during the summer. They were not such animals as would have been selected to give the best financial results, but being thin in flesh and fairly uniform, were well adapted to the purposes of the experiment. The twelve were closely shorn, and then divided into four lots of three each, in such a manner as to have as nearly as possible an equal weight in each lot. Three lambs were used in each lot, so that if for any reason there should be an accident to one there might be two left at the end, from which to gather data in regard to the effects of the rations.

The lots were numbered respectively III, IV, V, and VI, and each lamb was labelled with a separate numbered ear-tag, so that data in regard to increase in weight, etc., could be collected individually and by lots. The experiment progressed satisfactorily from beginning to end, with but two exceptions.

Lot III was fed what may be called a carbonaceous ration. The lambs were given all the timothy hay and whole corn they would readily eat, and in addition about a half pound of roots each per day. Turnips were fed as long as the supply lasted, after that mangels were used.

Lot IV was fed a nitrogenous ration, although it was not so excessively rich in nitrogen as that used by some experimenters in trials of this kind. The grain ration was made up of two parts wheat bran and one part cotton-seed meal. A pound per day per lamb of this mixture was fed at first; afterward it was somewhat increased or diminished, as the needs of the case required, the object being to feed about all that would be readily eaten. This lot received clover hay instead of timothy, and roots, as lot III.

Lot V was fed an intermediate ration. The grain part was composed of three parts corn and one part each of wheat bran and cotton seed meal. It was eaten in about the same quantity as lot IV. Timothy hay was used for this lot, and roots were fed as in each of the others. Lot VI was fed the same as lot V, except that they received no roots at all.

The lambs had access to water the whole time. In the winter it was warmed to about 80° before being offered them. The weight was obtained in the following manner. A pail of water was weighed and placed in the pen, where it remained till the next morning, the sheep drinking whenever they wished. Each morning the pail, with whatever water remained in it, was weighed back, the difference in weight being the amount consumed. A fresh pailful was then weighed out, and the process repeated. This was kept up during the whole course of the experiment. The water was warmed when it was first put in, and during the cold weather the lambs soon learned to take nearly all their water as soon as fresh water was given them. From the first a marked difference was seen in the amount of water consumed by the different lots, and this difference continued through the whole course of the experiment. The total amount of water drank was as follows: Lot III drank 308 pounds, or 1.03 pounds per lamb per day; lot IV drank 1,185 pounds, or 3.95 pounds per lamb per day; lot V, 735 pounds, or 2.45 per lamb per day; lot VI, 847 pounds, or 2.82 per lamb per day.

The very much larger quantity of water consumed by the lambs fed a highly nitrogenous ration is at once apparent. It will be seen that lot IV drank nearly four times as much as lot III (fed carbonaceous food), and about 60 per cent more than lot V. These three lots were all fed roots in equal kind and quantity, so that it would seem that the different amounts of water consumed must be due to the nitrogen in the ration.

Lots V and VI were fed on the same ration, except that lot VI had no roots. Probably for this reason they drank about 15 per cent more water. The lambs fed on nitrogenous food, or lot IV, made much the largest average gain, and those fed on carbonaceous food, lot III, made the smallest gain, though not very much smaller than lot VI. Animal individuality, a very perplexing consideration in all work of this kind, showed its influence very strongly.

Notwithstanding the gain in live weight was very markedly in

favor of the lambs fed on nitrogenous food, it is when we come to compare the amount of gain in relation to the amount and cost of the food consumed that the most striking figures are brought out. Both in the amount of food consumed for one pound of gain, and the cost of gain per one hundred pounds, the advantage is very markedly in favor of lot IV, the lot fed on nitrogenous food. It costs a little more than a cent and a half per pound, or twenty-six per cent more to put a pound of gain upon the lambs that were fed on corn, timothy hay, and roots than it did to put a pound of gain on those that were fed wheat bran, cotton-seed meal, clover hay, and roots.

The lambs were shorn Nov. 15, or ten days before the beginning of the experiment. They were shorn again the day before they were slaughtered, so that the wool obtained was the growth of 160 days. The weight of the wool from both lambs in each lot was, lot III, 4.25 pounds; lot IV, 7.31 pounds; lot V, 6.63 pounds; lot VI, 6.19 pounds;—the last three lots showing an increase over lot III of 72, 56, and 46 per cent respectively. This coincides with the results of the experiments last year, in that nitrogenous food seems to largely affect the growth of wool. It seems to show further that even a small increase in the nitrogenous matter of a ration has a decided influence on the growth of the wool, for lots V and VI, whose ration was intermediate in character, gave very nearly as much wool as lot IV. In the experiments of 1888, already referred to, the percentage was not so great in favor of the lambs fed on nitrogenous food.

The lambs were slaughtered on April 25. The blood was carefully caught in a clean pail, and it and all the important internal organs were weighed. The carcasses were hung up in a cool place to stiffen for two days, and were then cut up, and the parts carefully examined. Before they were taken down, however, they were weighed and most carefully inspected by the different members of the staff. The most striking difference that was apparent, as the carcasses hung upon the hooks, and after they were cut up, was the evident leanness of the two belonging to lot IV, which had been fed nitrogenous food. The kidneys were not covered, and there was very little loose fat next the skin, while in all the other carcasses the kidneys were more or less completely covered, and there was a layer of tallow of greater or lesser thickness between the skin and body. The carcasses of lot III had the most of this tallow. The same thing is shown in the amount of caul fat and kidney fat. While an expert butcher would have undoubtedly selected the carcasses of lots V and VI as furnishing the most saleable mutton, the carcasses of lot IV had little or no unpalatable adipose matter, and those of lot III showed much the largest percentage of waste fatty matter about the root of the tail and in the flanks.

The weight of evidence of all of the experiments at Cornell, together with results obtained by other experimenters in the same field, seems to show: that corn, as an exclusive grain ration, does not give the best results, either in amount, quality or economy of production, when fed to growing or fattening animals; that the amount of water drank, especially in the case of these lambs, is a pretty certain indication of the rate of gain; and that the production of wool is very greatly dependent upon the nitrogen in the ration.

The value of the manure made from the animals fed is a matter of prime importance, to all eastern farmers at least. And often the manure left on the farm represents a large part, if not the whole, of the profit made from feeding a lot of animals. For this reason there were calculated the manurial value of the rations fed the different lots. From this it appeared that while the first cost of the ration of the nitrogenous fed sheep was larger than that of the carbonaceous, yet when the value of the manure is subtracted, the cost of the former is less than half of the latter.

PEARL OYSTERS.

THE presence of nodules or tubercles on the interior surface of the shells or valves of lamellibranch (bivalve) mollusks is of frequent occurrence. These excrescences are nacreous or otherwise, according to the character in this respect of the shell in which or upon which they occur. They are found alike in fresh-water and marine species. In the pond and river mussels they are chiefly due to interior causes; in marine forms, like the cockles, mussels, the

scallops, etc., these formations are generally traceable to exterior causes. It is often the case that specimens of the large scallop of the New England coast are so burrowed into by a species of sponge that nearly the entire inside surface of the valves will be roughened with sharp, thickly-set pustulæ. In all the marine species in which those nodules occur it will usually be found that the substance of the shell has been bored into from the outside by either a species of pholad or lithodomus.

Neither of these forms are, properly speaking, either parasites or commensals. They are, more definitely, "domiciliares," as stated by Mr. Robert E. C. Stearns of the Smithsonian Institution, and excavate their burrows, not for the purpose of getting at the softer parts of the mollusk upon whose shell they have "squatted" in order to use said softer parts as food, but solely for the purpose of a residence or domicile.

The burrows of these shell-boring pholads and lithodomi are at first quite small, increasing in size in the same ratio as the burrower increases in age or in growth. After a while the depth of the boring is equal to the thickness of the shell in which it has been made, and the occupant of the latter, in order to keep his own shell intact and maintain the integrity of his own domicile, commences depositing layer upon layer of nacreous or porcellaneous matter, as the case may be. In keeping pace with the continued encroachments of the domiciliary squatter upon the outside, this deposit finally becomes a more or less conspicuous protuberance.

Sometimes these nodules or tubercles are due to some foreign inorganic matter, a particle getting in between the mantle of the mollusk and the inner surface of its shell. In such cases it is, we may say, at once plastered over, and thus fixed upon the surface of the valve. Free concretions, i.e., unattached or non-adherent nodules, are, as is well understood, caused by some particle, organic or inorganic, becoming in some way lodged exclusively in the soft parts of the body of the mollusk, and so far away from the surface of the shell as not to admit of its being cemented to it.

No doubt many of the mollusca, both gastropod and lamellibranch, contain or are inhabited by true parasites. In certain species of fresh-water mussels a species of water mite has been detected, and sometimes thread worms and other forms occur.

A small species of crab, an epicurean no doubt, finds a salubrious habitation in the common oyster, but parasites of any considerable size appear to be rather rare. Besides the species above referred to, another small crab is sometimes found in the common mussel and the large scallop before mentioned. It is doubtful, however, whether these crabs are really parasites or only commensals, though probably the former.

There is, however, evidence of the occurrence of fishes of two species as parasites in the true pearl oyster, or mother-of-pearl shell, not by the presence of the living fish, or even by dead specimens of "fish in the flesh," if we may use so convenient a paradox, but by their entombed remains in the form of nacreous nodulæ or tubercles on the shells or valves of the said mollusk.

At a meeting of the Zoological Society of London June 1, 1886, Dr. Günther exhibited a specimen of a small fish of the genus *fierasfer* embedded in a pearl oyster, and said: "This specimen is an old shell, in which there is imbedded, behind the impression of the attractor muscle, a perfect individual of a fish belonging to the genus *fierasfer*. The fish is covered by a thin layer of pearl substance, through which not only the general outlines of the body but even the eye and the mouth can be seen. The parasitic habits of *fierasfer* are well known. The fish, instead of introducing itself into the cavity between the two halves of the mantle, penetrated between the mantle and the shell, causing irritation to the mollusk, which the latter resented by immediately secreting the substance with which the intruder is now covered. It is remarkable to note that the secretion must have taken place in a very short time, at any rate before the fish could be destroyed by decomposition."

After entering the shell, which of course must be at such time as the valves are partially open or gaping, these fishes find no obstruction to their course as they push their way towards the interior between the mantle and the smooth inner surface of the valves until they approach the adductor muscle, and here they find a barrier which most likely causes them to expend somewhat greater ac-